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Higher education in industrial engineering in Peru: towards a new model based on skills

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Abstract

This article analyzes the progress of Industrial Engineering in Peru, the relationship to major trends in Europe and North America, and the projected outlook for the future. It is determined that the need for this engineering specialty includes a significant degree of resource management, and the formation of engineers through education requires not only the acquisition and strengthening of technical knowledge, but also the development of the competences that are required by both employers and the recipients of the benefits of engineering: society. Conclusions have been drawn based on state-of-the-art analyses from Europe and North America, and definitions of trends for engineering.

Keywords: Higher education, industrial engineering, professional skills, contextual learning;

1. History of engineering action in time

Present-day engineering is a profession in which the knowledge of basic science is applied to the efficient use of materials and forces of nature in order to meet the growing needs of humankind. Its development has been linked to the history of nations, as it reflects how humanity has adapted the world to meet its needs, as seen by the technical achievements that have been made.

Thus, it can be seen through the history of humankind that the initial discipline was a profession that strove to improve quality of life. The stages of human development can be marked by the findings of technical activities through history. One example is the Agricultural Revolution, which helped humanity to transform from a nomadic to sedentary lifestyle through the ingenuity to meet and fulfill basic needs by using craftwork, military activity, irrigation and construction. According to some historians, these changes arose in Syria and Iran staring in 8000 BCE. This shift in migration created new needs and demands. Consequently, the regions that were found along the overland route from China to enjoyed an advantageous position along with significant contributions of knowledge from emigrants, who simultaneously served as carriers of the knowledge they felt compelled to develop. These regions include the Middle East and the Mediterranean Sea, and stand out in history as cultures with the earliest development of engineering: Egyptian, Mesopotamian, Eastern Europe, Greek and Roman cultures. Within these cultures, scientific and technological advancements were promptly developed.

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The Roman Empire definitively fell in 476 AC. Within Europe contributions to engineering also declined between the years 600 and 1000 AC. Regardless, the precedent to modern technologies can be found in artisans, soldiers and medieval builders. War has always been an incentive for the development of human ingenuity, and as such, contributions from Asia arrived through invasions and the Silk Road.

During the High Middle Ages, between approximately 350 and 1050, each town formed its own culture but each one recognized the common core of the Christian-Roman legacy transmitted by the written Latin culture. This was a time of renewed artistic and intellectual vitality, wherein educational institutions flourished and interest in ancient culture was renewed. This need for intellectual advancement was preceded by various countries and regions in the form of advanced schools and later, universities.

2. Home of engineering in Europe and the U.S. (Garcia B, 2010)

In the year 900 A.C. there were approximately 20 universities in Europe and in 1000 AC there were 200, an increase that can be credited to their mandatory creation in cities with cathedrals. In major European cities between the years 1088 and 1167, many universities emerged to study the seven liberal arts: arithmetic, astronomy, geometry, grammar, logic, music and rhetoric. The first were found: in Italy, Bologna and Salerno; in France, Paris, Chartres, Reims, Laon and Soissons; in England, Oxford in 1208 and Cambridge in 1209; in Spain, Salamanca in 1218.

In the late Middle Ages, about 1400 A.C a technological revolution emerged and spread throughout different disciplines, taking the forms of mining, post, cartography, census collection, and the transportation pathway development of highways, bridges, canals, locks and tunnels.

During the Renaissance, intellectual life surged throughout in Europe, including the schools of engineering and science. It began in Italy before 1400 and extended through the rest of Europe. Consumerism emerged in Europe with the exchange of luxury items. This trade promoted the improvement of navigation technology. Professor Lockard, of the University of Wisconsin, says: "Globalization first laid its roots between the eleventh and sixteenth centuries…" (Lockard, CA, 2010)

While the organized study of science and technology spread throughout the New World, the Industrial Revolution began in Great Britain, the beginning marked by the use of the steam engine for industry in 1780.

Until the late eighteenth century, the engineering profession as we know it today did not exist. The buildings were built intuitively on the basis of trial and error and according to the previous traditions of construction.

During the sixteenth and seventeenth centuries in Western Europe established true factories. The industrialization was led by the basic principle of the division of labor. It addition to mass production, industrialization also led to the specialization of labor and the increased interaction between science and industry. Likewise, it began the accelerated and indiscriminate use of natural resources and also the serious social problems that are derived from industrial machinery: the replacement of man by machine. This meant that man simply became a resource for production. Industry took space away from agriculture and technology displaced the use of the plow and oxen.

The Renaissance, the Enlightenment and the demands of the Industrial Revolution forced the creation of specialized centers for sciences and various branches of technology. The first engineering schools in France, initially military-based, argued that different jobs required different skills, which must be properly developed. In England, "The Industrial Revolution was made by hard heads and smart fingers." As a result, professional associations were created. One of which was the Institution of Civil Engineers (1818), who with the boom of the railroad specialized themselves as the Institution of Mechanical Engineers. It was during the second half of the nineteenth century that engineering arrived to the universities of Glasgow, Durham and London. In Germany in the late eighteenth century and early nineteenth century workshop culture and the cottage industry still prevailed. Although the Polytechnic University of France maintained a strong impact on the cultural environment of the region, it was not until 1809 that the "modern university" arose in Berlin, such being a center that combined teaching with research. By 1820 various polytechnic universities were set up in Berlin, Karksruhe, etc. From these schools emerged electrical, mechanical, chemical, and civil engineers. Really, these graduates were middle-level technicians who had great influence on German industrial development. By the end of the century these schools had reached university status and simultaneously the universities were incorporating engineering studies. The growth of these schools can be distinguished by their combination of teaching, research, laboratory work, and a constant relationship with modern industry, a process that became increasingly more complex from a scientific point of view. Between 1850 and 1900 Germany and England competed for industrial hegemony, which was reflected in the education of their engineers.

In the United States of America, engineers came from the British Empire, until it gained independence. Their war of independence tied the United States closely to France, to whom they requested technological support. As a result, West Point Military Academy was created in 1802. The first civil works projects and mines were made with designs from Europe, by military engineers from the Academy. Universities and technological institutes collected French, British and German schools of thought, and imposed technical education following the Civil War (1861-65). With a strong emphasis on practice and a promotion of laboratory work, these schools linked engineering students with jobs (Half time schools) without neglecting the importance of the theory.

3. Engineering in the European Higher Education Area

The concept of the European Higher Education Area first appears in the Sorbonne Declaration of May 25, 1998. The statement expresses the wish to create a European area dedicated to higher education. Subsequently, through the Bologna Declaration of June 19, 1999, steps were defined for following this ambitious process of convergence. Later, in the Prague Communiqué of May 19, 2001 additional details were introduced. Firstly, education throughout life is an essential element for the achievement of greater European competitiveness, improvement of social cohesion, establishment of equal opportunities and quality of life. Secondly, the active role of the universities, institutions of higher education and students in the development of the convergence process, as well as the creation of quality assurance systems and means for certification and accreditation. In 2005 the Conference of Bergen was held. Its main findings focused on the Bergen Communiqué, signed by its 45 attendees. It highlighted the progress and outline the three primary challenges ahead: the creation of closer links between higher education and research with the incorporation of the PhD as a connection between them; the development of the social dimension in higher education by improving conditions for equal access, acceptance and attention to students and financial resources; and the international dimension regarding the mobility of students and university staff. (Canós, L. et al, 2009)

Europe has two different educational models: the Anglo-Saxon and the Continental. The Continental systems are very similar and mainly follow two basic models that coexist: a long cycle and a short cycle. Anglo-Saxon countries have a model of two consecutive cycles. It is very unique and creates confusion, both in Bachelors and Masters programs. The confusion and complexity are increasing.

The industrial engineers who have obtained higher-level degrees have played and play a decisive role as transmitters and introducers of progress. The balanced combination of a solid scientific and technical education, different applied technologies and disciplines within the economic-business and social-humanistic areas, the understanding that comes from the reality of the industrial sector (from a broad and global perspective) and the ability to interrelate various disciplines involved in complex systems (create, develop and manage), makes these studies a current and innovative model, applied by many European universities. The formation of a Generalist Industrial Engineer with knowledge of the different techniques and the ability to integrate the industrial thinking of Europe cannot be achieved with a university period of less than five years. The best education is the current model: an integral cycle within which from the beginning one gets the basic knowledge and "a good foundation", so later one will be able to apply the specific techniques in-depth. Such learning process ensures that no possible technological innovations escape, thus requiring the understanding of the overall picture. (Romero, F, 2003).

Industrial Engineering studies are considered basic to the economic development of our society. The industrial sector consists of four basic types engineering: mechanical, electrical, chemical and organizational (Elsayed, 1999).

As a result of the integration into the European Higher Education Area, we are currently witnessing a change in the degree requirements and structuring within the European university systems. One of the studies with the largest output of professionals is Organizational Engineering, due to the constant growth of the field and demand for qualified graduates. We must also clarify that and Organizational Engineer is referred to as an Industrial Engineer in American terminology. (Canós, L. et al, 2009)

It was during the industrial revolution that the need for organizational engineering emerged. With the works of F. W Taylor in 1911: *The Principles of Scientific Management*, and H. Fayol in 1916, *Administration industrielle et générale*, the concept to scale, control units, the principle of exception, the authority angle, the specialty of organizational engineering and the application of scientific method, were applied. The literature maintained an absolutely mechanistic view of humankind and following: the principle of formal relationships, the importance of economic motivation, objectification, mankind's natural laziness, centralization, delegation, specialization (division between mental and physical), and universality (De Miguel, 2005).

With the evolution of the university in Europe, and the increasing need for organizational engineering, we can say that the organizational engineer is a professional with a solid mathematical and statistical background, who knows what the subjects are, what they are used for, and how to implement them in an enterprise through operation management tools, in order to allow to offer products and services in the shortest time with the most productivity, quality, reliability and efficiency possible. He is also able to diagnose problems, analyze them, suggest ways for improvement and decide which of the management operations tools should be used or should not be used in their area of responsibility. To make this decision he must be able to assess his company's strategic priorities, key indicators, resources, benefits and expected costs, business conditions and technological limitations of the products and services offered by the company, have knowledge of the processes used in production, and be aware of the social responsibility corporate. Once the decision is made, he is able to assist in the implementation and monitoring of the proposed actions by defining the protocols, calculations, plans, programs, simulations, etc., which are necessary to carry out the decision. He will also have an important role leading and motivating people who must collaborate in the implementation of the task. (Marin-Garcia, J.A, et al., 2008).

An organizational engineer has a distinctive feature, and it is that his field requires a broader and stronger mathematical and statistical base than the other branches of engineering. It also requires programming skills to automate the calculation of algorithms that he customizes. In contrast, mechanical engineering will require more physics and knowledge of chemistry and energy. (Gallwey, T. J., 1992)

In Spain, the career of organization engineer is welcomed by the business world and 50% of graduates find work within six months. Most of the organization engineers (60%) work in large companies and their average salary is about 9,000 Euros more than other engineering disciplines. The main variables of satisfaction say that they are the content with their jobs, the prospects for improvement and the level of salary. On the contrary, they are very dissatisfied with the knowledge and skills acquired during their university education. (Martinez Costa et al., 2007). It is clear that several authors point out that in Europe the universities do not emphasize post-graduate training of graduates in organizational engineering. (Markes, I., 2006)

Currently universities have only a limited role in the post-graduate development of professional organizational engineers. Regardless, for the health of the entire system, it is vital that universities fulfill this role completely. If universities continue to neglect to seek ways in which to collaborate with the training of professionals post-graduation, they will have to accept an early end of their involvement in professional development. Furthermore, with time, the will have to accept that they may lose their status of authority over other institutions in the field of higher professional development. (Maffioli, et al, 2003)

The degrees and careers of organizational Engineers is essential for a country that hopes to maintain or boost the competitive advantage of their businesses. While there is a tendency to deny the creation of the distinct and independent study of organizational engineering, it is necessary to provide a specialty degree in this area in universities where this demand is detected, or apply a program of industrial engineering with a master's degree program in organizational engineering when the demand does not justify the creation of this specialty program. (Martinez Costa, et al., 2007)

Engineering in the USA

Civil Engineering was the first engineering discipline to attain professional status en the USA. In the mid-1800s mechanical engineering appeared in mechanic workshops for weaponry, tools and other sophisticated devices. The demand for engineering goods and services grew with the population and to respond to this and other educational needs, the federal government began to support higher education in 1862. A federal subsidy gave further support to engineering education, enabling a more scientific approach to technical problems. As a result, the engineering profession began to diversify (NRC, 1985).

From mechanical and civil engineering grew mining and metallurgical engineering. Then the fields of electrical, chemical, and industrial engineering appeared. Industrial engineering began as an area of mechanical engineering, developed to further systemize the manufacturing processes. By then, the five disciplines of engineering – civil, mechanical, electrical, chemical and industrial – had established themselves as the major programs.

The traditional industrial engineering program that we know today comes from Taylor´s studies of “work design” and the “method of study”. As interest for industrial engineering grew, related areas developed and later became principal components in the field of industrial engineering. For example, the development of operations research in the United Kingdom in 1940 and the interesting problem that it investigated led to its adoption by the US Army, Air Force and Navy. One of the first courses in operations research in 1948 was offered at the Massachusetts Institute of Technology (MIT). Case Western University became the first university to offer a degree program and shortly after, universities such as Northwestern and Johns Hopkins referred to operations research. Other related areas include management and organizational behavior. This has recently extended to the management of technology, operations management, quality management and engineering management. In fact, engineering management grew at such a high rate that it became an independent discipline in some universities. Similarly, industrial engineering pays attention to humans and amplifies this through courses such as ergonomics or human factors, that are considered to be sub-disciplines of industrial engineering and are closely related to industrial and experimental psychology (Elsayed, 1999).

Manufacturing engineering is naturally associated with industrial engineering in training programs in many universities. However, the introductions of subjects such as statistics, probability and operations research have resulted in the reduction or elimination of the course offerings in the area of manufacturing engineering. In the 80´s when the Japanese products began to control major aspects of the market, the government and the universities in the USA responded by promoting manufacturing engineering. Courses related to manufacturing processes, manufacturing engineering, systems design, and production systems were added to the curriculum of engineering. The courses listed are still part of the main curriculum of many industrial engineering programs in the USA. Additionally, required courses in physics, mathematics, humanities, and social sciences gave rise to the four-year of degree program. Fortunately, programs are not identical. The inclusion or deletion of the previous courses depends on the experience, training and background of the faculty and staff. Some programs tend to offer more courses in management, human resources and business, while others tend to offer more courses in manufacturing processes, design and engineering sciences. (Elsayed, 1999).

4. Industrial Engineering in Peru

Industrial engineering emerged in Peru with different names due to the need to improve the design and implementation of processes, and was aimed to increase the quality and productivity of businesses. This led major universities to implement the teaching of this new branch of engineering. Over time, the field was formalized and unified under the name of industrial engineering at universities.

The first university to offer Industrial Engineering in Peru was the National Engineering University (UNI). The faculty was founded in 1901 under the name “Section of Industrial Engineering”, and was third section created at UNI. In 1937 it was renamed as “Section of Industrial Chemical Engineers” and by 1946 the name was changed again to be the “Industrial Chemical Engineering Department”. On April 23, 1959, the university council changed the name to “Industrial Engineering Faculty” which lasted until 1969, when the university established the departmental system, which gave birth to the Industrial Engineering and the Systems Engineering programs. Later, in 1984, it returned again to the faculty system, which is effective to date.

The second university to institute Industrial Engineering degree in Peru was the Universidad Nacional de San Marcos (UNMSM). In 1953 it created the Institute of Human Relationships and Productivity, in order to investigate the most pressing human problems caused by the economic and social development. In 1960, the institute led to the creation of the Graduate School of Economic Science, and trained experts in Public Relations and Advertising, Industrial Relations, and Industrial Engineering of Production and Management. In October 1965, it became the Industrial Engineering Academic Program. As a result of this change, the first Industrial Engineering curriculum was developed and structured, and has had several transformations until the present version.

In the 60´s several other universities in the capital and beyond began this degree program. These universities started the program with the formal name of Industrial Engineering. One of them is the Pontifical Catholic University of Peru (PUCP). The Engineering Faculty began its academic activities in 1933. An agreement in 1965 with the Ford Foundation led to significant changes because it made possible the establishment of a department of basic Sciences, which allowed an increase in the faculty's curriculum and enhanced the areas of mathematics, physics, chemistry and some branches of the industrial, mechanical and mine engineering. In 1966 it created the Department of Basic Sciences.

In 1981 at the First Peruvian Congress of Industrial Engineering and Related Fields, the Industrial Engineering curriculum of UNMSM; UNI and PUCP were very useful in determining the "minimum required curriculum" for the professional training of Industrial Engineers within the country. It should be noted that the creation of a curricular structure was successful and did not complicate the manner in which teachers taught the contents of different subjects. Later in 1991, the curriculum outline was confirmed after an analysis conducted by the Board of the Industrial and the Systems Engineering Chapter of Lima of the School of Engineers of Peru.

Presently, there is a project attempting to change the curriculum, developed by the Curriculum Change Committee, and the new curriculum will be evaluated by a review commission for its approval by the councils of various universities: Universidad San Ignacio de Loyola, Catholic University of Peru, University of Engineering, University Mayor de San Marcos, and Peruvian University of Applied Sciences.

These are five-year curriculums, with a solid content of statistics and operations research. It is also strong in the realm of management and operations management and maintains an administrative, social and humanistic component. No curriculum ignores the basic sciences or mechanical, electrical and systems training.

In the beginning, industrial engineering in Peru was not strongly welcomed by society beyond the prospects business developments, which were limited. However, over the years, the world was globalizing, forcing small businesses to survive in an industrialized market. At present, industrial engineering is one of the most sought after careers in all of the systems by business.

The *Business Barometer*, a survey to measure the demand of professionals in businesses, was developed by the Public Opinion Group of the University of Lima. Its intent is to determine the demand status for university professions by surveying in the four thousand companies with the highest billing in Peru in 2007. (Opinion Group: 2007). The study-group is composed of these four thousand companies according to the rankings of Peru: The top 10,000 companies in Peru.

The survey suggests that the hardest-to-find professionals are, in this order, mechanical engineers (12.8%), accounts (9.6%), and industrial engineers (7.6%). In response to the question: "What college degree does your company most demand?" The answer was Industrial Engineering with 20%. To answer the question: "What college degree will your company demand most in the next 10 years?" The answer was Industrial Engineering with 18%. In response to the question: "Which of the following professions do you consider to be the most-needed for the nation?" The first coice was Industrial Engineering with 15%. (Groups 2007).

Today, Industrial Engineering is a profession with great leadership. The current industrial engineer is multi-disciplinary scholar, able to face challenges due to his scientific background and management training, and is well-versed in information technologies. These capabilities give him versatility, flexibility and enhance his decision - making process. In recent years the emphasis has been on design and creativity, research, development, and innovation.

5. Current Trends

"For the preachers of globalization, higher education can be reduced to a subsector of the economy, highlighting the notion of the involved resources and the virtually unlimited amount of customers. In the future, paths laid by delusional and enthusiastic addicts to technology, higher-education will be a shocking system of

perpetual training through images shared by cyber-users internationally, and will be preserved from political concerns, protected from the bitter worries of inequality and injustice, and without primitive sensations of a commitment to society."(Imbernon, et al. 1999)

However, we know that higher education is more complex. To determine which direction higher education or a curriculum in industrial engineering in Peru should take, many variables must be taken into account. For example, the global context, international policy for curriculum levels, national trends in Iberian and Latin American engineering, recommendations from international lending agencies for reforms in higher education, the ability to meet the demands of the production sector, and an analysis environmental and social gaps, among others.

In the vision of European higher education current and future goals stand out: learning focused on the active role of students, mobility and relevance of graduate and doctoral programs, accreditation, professional associations, and professional contextualization. This requires achieving a shift from school-based teaching to one based on learning. Undergraduate students should seek learning as an essential step to enable continuous education and learning. (Suarez A., B., 2004) The second level, or official post-graduate level, is a strategic goal to give relevance to the training process and give international visibility of the European higher-education system, thus permitting the mobility and ability to facilitate scientific and technological development. This accreditation allows different educational systems to be testable and the European Credit Transfer System (ECTS) considers the whole student work dimension beyond the mere transfer of information. Then, the objectives of the educational process will turn to training aimed at ensuring that professionals perform in an academic environment, with strong background in the consolidation of the technical merits, abilities, skills, attitudes and skills. (Zambrano, J. et al, 2009)

Europe seeks its own definition of convergence. European development requires a combination of different technologies, and to take part in these sectors is a guarantee of competitiveness of engineering in Europe. At the same time it must direct its development towards improving the functioning of society. Plans should be designed scientifically and technically to improve focus on research and development efforts aimed to satisfy the main demands of society. (Roco, M., et al, 2002). This convergence should go a long way when society shifts to an information-based society to a knowledge-based society.

Recently the United State has experienced a change of practical focus to one more related to academic focus within the science of engineering. This allows graduates to have sharp technical skills, but is not well prepared for the other practical skills necessary for present-day engineering and development of innovative technology and management. (Padros, J., 1998)

It should also be considered another part of reality. There is a decreased demand for new engineers in manufacturing industries. The research and development, a formerly glamorous area that is used to attract the best and the brightest students to engineering, has decreased the number of attractive offers in the last years. The service sector has shown a sharp increase in the number of jobs held by young engineers: medicine, health, justice, business management, consulting, financial engineering, environment and safety. Some argue that engineering education must prepare students for the manufacturing industry, while others consider it to be a prelude to exciting careers. It is clear that more and more engineers are working in services than in industry. During the last decade at the Princeton University, no more than a quarter of engineering graduates had his first job in manufacturing companies. The education of engineers has traditionally been designed to train students for jobs in the manufacturing and construction, and curricula are designed to teach students how to build useful devices and how to use them for the benefit of the people. However it is believed that in the future, engineering will be more related to the services than to manufactured goods. (Wei, James, 2005)

Engineering educators must rethink how to educate students for the changing markets for future jobs. Employers in the service sector already use more than half of all engineers due to their abilities to reason quantitatively, apply the scientific method to solve complex problems, and to manage systems with multiple objectives and criteria. Engineering educators must retain all the positive attributes of engineering graduates that are valued by the service sector, but should also consider the possibility of de-industrialization as an opportunity to enrich their offer. It should start thinking more broadly about the question: "What are the greatest achievements of our profession in shaping and inspiring our students?" Rather than just "What are the tools they most urgently need in their toolboxes?" (Wei, James, 2005).

In 2004, the National Academy of Engineering published a report entitled "The Engineer of 2020: Visions of Engineering in the New Century", which concludes in the executive summary that "engineers must adapt to new trends, and educate the next students generation arming them with the necessary tools for a world that no longer be as it is today. "

Strategies to infuse global perspectives in industrial practice and engineering programs should be included. Institutional support is necessary so that programs can take that approach. If a university lets teachers alone to do, the efforts are less effective and difficult to maintain over time. There may be technical skills and techniques with the right balance, together with adequate exposure to the global world, will allow the next generation of engineers to be well prepared to face future challenges. (Jackson, H. et al, 2010)

6. Industrial engineering approach to Perú

In Peru there are 25 universities dedicated to professional training in Industrial Engineering, nine are public 16 are private. Of these 25 universities that teach industrial engineering in Peru, 14 (56%) are located in the Department of Lima (five public and nine private). In Lima, the capital, Industrial Engineering is one of the most offered degrees, as almost half (48%) of universities have that specialty. There was an increase in the number of admissions, which makes it very competitive for these professionals to find a job. 70% of industrial engineers work in jobs that are related to their field, 20% perform jobs that differ from their vocational training, and 10% are without a job. Their work is related to the service sector (60.8%), in fields such as trade activities, transportation, and communication. In the industry sector (34.8%), graduates work within fields of textiles and apparel. Finally, in the extractive sector (4.4%), principal jobs are in regards to mining activity. The jobs where they work are mostly related to the functional area of production (18.5%), marketing (17.6%), logistics (15.3%), business administration (9.4%), organization and methods (8.1%) and quality control (6.3%). (Alvarez, Mary, 2005)

The situation in Peru is similar to the U.S. in terms of increased involvement of industrial engineering in the service sector. Since the beginning of engineering in Europe, the USA and Peru, the men and women who devoted themselves to the field did so in response to the needs of the environment. In all three cases, industrial engineering was born by industrial and social pressures after the Industrial Revolution and later linked to mechanical and chemical engineering.

According to the history of engineering in Europe and USA, we can say that there are common ties to the development of engineering in Peru and therefore the tendencies of industrial engineering must be taken into account in order to achieve a national profile that meets modern requirements.

Industrial engineering in Peru should take into account the need to give professional identity to students. It must integrate classroom learning with external practices events. Students can participate in group learning projects and activities such as exchange programs or internships, which are experiences that can integrate coursework with a real, professional context. Reflective writing about their experiences and opportunities to make decisions are unique moments of stimulation of professional identity. (Eliot, M; Turns, J, 2011)

For Don Evans of Arizona State University, one should consider student diversity. The number of ethnic, gender, racial, economic, and disabled students will increase and this diversity should be encouraged. Students come to college with different backgrounds and experiences, and meaningful context and for one student will not necessarily be a meaningful context for another. The result of this challenge is that the educators of engineers will have to work harder to ensure that all students’ needs are met. (Shuman, Larry J., et al, 2002).

Technology and science are developing so rapidly that engineering students cannot be taught the fundamentals and latest advancements, and therefore it is impossible to know and do everything that the profession requires. It is therefore desirable to stimulate an international contact network of students to enable them to learn how to address problems in other countries and other cultures. Current engineering students will be living in a globalized world, so it is desirable to have experiences in which they may understand that an engineering problem has no single solution, but rather many different approaches and perspectives, all with effective and creative solutions. (Hansen, Jorgen, 2004)

Students in the near future will have to choose between (a) passively attending classes at certain locations and times on campus with a curriculum based approach and (b) the performance of interactive multimedia tutorials at any time and place in a certified institution. It is likely that programs based on the traditional curriculum that requires attendance on campus is becoming less attractive to prospective students. The potential impact on traditional campuses that do not meet the challenge is not pleasant to contemplate (Felder, RM, et al, 2000)

Thus far it has been firmly believed that graduates should be able to solve engineering design problems. However, engineering programs must begin to meet the growing demand for technical graduates that put their skills in action to solve problems as it was before the creation of the liberal arts program. The teaching of undergraduate engineering will continue to expand its outreach to the arts, humanities, social sciences or business, as well as technological changes affecting the market. The teaching of engineering degrees will be larger and full of liberal arts studies, thus providing graduates a base for advanced studies in engineering, while opening the doors to solve technological problems in engineering and apply this knowledge to the general needs of society as it did formerly. (Smith, K.A., Prados, J.W, 2000)

For Charles Yokomoto, Indiana University-Purdue University Indianapolis, students will have to become better students, develop a deeper understanding of the basic principles, be better problem solvers, be increasingly innovative and creative, and work more effectively in teams, while at the same time must become more skilled in basic engineering procedures, protocols and methods. They will have a better education in the liberal arts and social sciences because problems become more complex due to the inclusion of social and environmental factors. Engineering professors will have a better understanding of teaching methodologies, how people learn at a cognitive level, of student motivation, and of use of technology and software development. (Shuman, Larry J., et al, 2002).

To set the groundwork for an appropriate profile for the industrial engineer in Peru we can rely on the considerations made by John A. Marin-Garcia et al, for the Spanish Organisation Engineers:

"Among the different profiles that can be proposed for the Engineering Organization (ANECA, 2005), there are two fairly widespread interpretations of the engineering title (Elsayed, 1999; Gallwey, 1992). The first of these interpretations, operations management, is consistent with the vision of Industrial Engineering of USA, UK and Holland and has a close relationship with manufacturing engineering and industrial engineering (ABET & EUR-ACE 2007; ANECA, 2005). The other view, coincides with management engineering in the United Kingdom and the USA, the German-style of WirtshchaftIngenieur, and of managerial and engineering in Italy. It is better associated with business administration and management (ABET & EUR-ACE, 2007; ANECA, 2005; Yannou & Bigand, 2004). If the title is framed in the industrial sector, we understand that the prime focus of the title should be marked by the management of operations, including business administration, and still leave room for other views (innovation development or consulting) and strengthens as is optimal. If the title framed in the social sciences, the prime focus would be the administration and management of business, thus leaving operations management as a complement or as an elective. "(Marin-Garcia et al, 2009)

With the speed of technological change, the need to perform in multidisciplinary and cross-cultural environments, the requirements to address and resolve environmental problems, the unavoidable contextualization of knowledge in reality, it is impossible to provide graduates with solid technical knowledge, and instead the must be equipped with competences to deal with current challenges. The mastery of professional competences and the ability to be innovative will give graduates of engineering the ability to prevent themselves from falling into technical obsolescence quickly, thus allowing them to continue the development of skills by learning in their world.

The professional competences are essential. We propose to divide them into two categories. In the first category are communication skills, teamwork, and the ability to continue with lifelong learning. In the second one are the skills for understanding the impact of the global and social factors, the ability to recognize and resolve ethical dilemmas, and awareness of contemporary issues. We can label the first set as process skills, because students learn a specific process for each one. Conversely, in the second set, awareness skills enable students to learn to be cognizant of the importance of their actions to the recipients, and to include them in their problem-solving activities. (Shuman, L. et al, 2005)

Conclusions

- European and American engineering developments have traveled similar paths, and in Peru, these same paths have been taken, so it is imperative to take into account the European and American trends in order to shape industrial engineering appropriately in Peru.
- Since its creation, engineering has responded to social, business and environmental requirements. n the future it should keep considering this task and therefore programs of stud must balance engineering content with liberal arts and humanities in order to form graduates with tools to act within the complex human networks that surround technical problems.
- It is essential for an engineer to acquire a professional identity during his undergraduate education, and contextualize their learning to meet the realities of their environment. This will require learning processes that encourage student mobility, assimilate to transculturation, and advocate the differences between students to allow them to move closer to practical, real situations in their programs.
- In the coming years engineering programs will need to emphasize competence training beyond specialized knowledge. Employers and society require basic skills to deal with rapid change: competitiveness and innovation. Failing to provide the opportunity to the student to develop competences will disadvantage the graduate in the changing and demanding world.
- Industrial engineering has shifted its focus after the Industrial Revolution, from the man to machine replacement and the Taylorist approach, to the information generation, in which everything is given. The future student will ask if he will be required to attend to a training center. The possibility of obtaining instruction at home with fully accredited information will need to be evaluated to see if the skills sought after are achieved in the format of convenient distance learning programs.
- Technology changes so fast and is so abundant that engineering graduates cannot stay up to date with state-of-the art technology in their specialty post-college. The technology-based individual will not be the one that knows the most about a specific area, but the one who is able to function in a changing environment with comfort and respect for society and the environment. Graduates should be able to master the techniques of their area and show sufficient ability to manage the resources allocated in favorable or hostile environments.
- The modern industrial engineering should pay attention to all the variables mentioned in this text and will have to do it quickly and decisively. The possibility that other institutions can become accredited and offer different options wit distinct attributes may attract young students and lead to an uncertain future to the university system.

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